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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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09/994,395

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EXAMINER

MAGEE, THOMAS J

ART UNIT

PAPER NUMBER

2811

DATE MAILED: 01/24/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

H.A

<b>Office Action Summary</b>	Application No. 09/994,395	Applicant(s) LOPATIN ET AL.	
	Examiner Thomas J. Magee	Art Unit 2811	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --  
**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

#### Status

- 1) ☒ Responsive to communication(s) filed on 28 October 2004.
- 2a) ☒ This action is **FINAL**.                      2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

#### Disposition of Claims

- 4) ☒ Claim(s) 1-4, 6-13, 15-20, 22 and 23 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-4, 6-13, 15-20, 22, and 23 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

#### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
 Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
 Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

#### Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All    b) ☐ Some \*    c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
  2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.

#### Attachment(s)

- |  |   |
|--|---|
| 1) <input type="checkbox"/> Notice of References Cited (PTO-892)   | 4) <input type="checkbox"/> Interview Summary (PTO-413)<br>Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)                                   | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152)             |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)<br>Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____  |

## DETAILED ACTION

### *Claim Rejections – 35 U.S.C. 103*

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office Action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

2. Claims 1 – 3, 6 – 8, 10, 13, 15, and 16 - 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Joshi et al. (US 6,030,895) in view of Edelstein et al. (US 6,399,496 B1), and Bogel et al. (US 6,749,699 B2)

3. Regarding Claims 1 and 10, Joshi et al. disclose a method for fabricating an integrated circuit, the method comprising:

providing a first conductive layer (M1) (Figure 2) over the integrated circuit substrate, forming a barrier layer (40,46) (Figure 2) (Col. 4, lines 50 – 62) along the lateral sidewalls and bottom of a via aperture, where the via aperture is configured to receive a via material that connects a first (M1) (Figure 2) and second conductive layer (M2), and depositing a copper via conformal layer material (Col. 8, lines 5 – 8) that comprises a ternary Cu alloy (Col. 8, lines 24 – 27).

Joshi et al. do not disclose the constituents of the ternary alloy. Edelstein et al. disclose that the ternary alloy (Col. 8, lines 49 – 52) can be formed using Cu, Zn (Col. 8, lines 42 – 45) and Cr (Col. 8, lines 35 – 41) and formed in a via, wherein the Zn is added to lower resistivity. Neither Joshi et al. nor Edelstein et al. disclose that Cr additions to the copper alloy increase and subsequently stabilize the grain size. Bogel et al. disclose that Cr additions to the copper produce an increase in grain size (Col. 7, line 65 through Col. 8, line 10) (Figure 3). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Bogel et al. and Edelstein et al. with Joshi et al. to provide a stable Cu alloy layer with improved electromigration properties.

4. Regarding Claim 2, Joshi et al. do not disclose that the copper alloy via material includes Ag. Edelstein et al. disclose the use of Ag as an alloying element for Cu. (Col. 8, lines 42 – 45). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Edelstein et al. with Joshi et al. to provide a stable Cu alloy layer with improved electromigration properties.

5. Regarding Claim 3, Joshi et al. do not disclose that the copper alloy via material includes Zn. Edelstein et al. disclose the use of Zn as an alloying element for Cu. (Col. 8, lines 42 – 45). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Edelstein et al. with Joshi et al. to provide a stable Cu alloy layer with improved electromigration properties.

6. Regarding Claim 6, Joshi et al. do not disclose that the copper alloy via material includes Cr. Edelstein et al. disclose the use of Cr as an alloying element for Cu. (Col. 8, lines 35 – 41). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Edelstein et al. with Joshi et al. to provide a stable Cu alloy layer with improved electromigration properties.

7. Regarding Claims 7 and 8, Joshi et al. do not disclose that the element for increasing grain size is Cr. Bogel et al. disclose that Cr is the element for increasing grain size (Col. 2, lines 8 – 15) is Cr (Col. 7, line 65 through Col. 8, line 10) (Figure 3) and that the concentration is 0.4% (less than one atomic percent) (Col. 7, lines 65 – 67). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Bogel et al. and Edelstein et al. with Joshi et al. to provide a stable Cu alloy layer with improved electro- migration properties.

8. Regarding Claims 13, 15, and 16, Joshi et al. do not disclose that the ternary copper alloy via includes one atomic percent or less of an element for increasing grain size or that the element is Cr. Bogel et al. disclose that the element for increasing grain size is Cr (Col. 7, line 65 through Col. 8, line 10) (Figure 3) and that the concentration is less than one atomic percent (Col. 7, lines 65 – 67). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Bogel et al. with Joshi et al. to provide a stable Cu alloy layer with improved electromigration properties.

9. Regarding Claims 17, Joshi et al. disclose a method of forming a via in an integrated circuit, the method comprising:

- depositing a first conductive layer (M1) (Figure 2),
- depositing an etch stop layer (34) over the first conductive layer,
- depositing an insulating layer (14) over the etch stop layer, whereupon, an etch is applied and an aperture formed in the insulating layer and etch stop layer,
- providing a barrier material (40,46) at the bottom and sides of the aperture,
- filling a via aperture with copper alloy to form a ternary via, and
- providing a second conductive layer (M2) formed over the via, electrically connecting first and second conductive layers.

Joshi et al. do not explicitly disclose that the addition of select alloying elements with an element for increasing grain size within the copper vias. Bogel et al. disclose a ternary copper alloy layer containing Cr and Sn.

Further, Bogel et al. disclose the addition of Cr element to the copper alloy for grain size increase (Col. 7, line 65 through Col. 8, line 10) (Figure 3). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine Edelstein et al. and Bogel et al. with Joshi et al. to obtain a ternary copper alloy with large grain sizes for vias.

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10. Regarding Claims 18 and 20, Joshi et al. do not disclose a copper alloy material that includes Cu, Sn, and Ca or that the compound source includes CuAgCr and CuSnCa. Edelstein et al. disclose that a ternary copper alloy (Col. 8, lines 49 – 52) can be formed comprising the following: CuAgCr (Col. 8, lines 35 – 45) and CuSnCa (Col. 8, lines 31 – 41). It would have then been obvious to one of ordinary skill in the art at the time of the invention to use the ternary alloy of Edelstein et al. in Joshi et al. to obtain a filled via with a combination of electromigration resistance, adhesion, and surface properties (Edelstein et al., Col. 8, lines 51 – 52).

11. Regarding Claim 19, Joshi et al. do not disclose the constituents of the Cu alloy. Edelstein et al. disclose that a ternary alloy (Col. 8, lines 49 – 52) can be formed using Cu, Zn (Col. 8, lines 42 – 45) and Cr (Col. 8, lines 35 – 41) and formed in a via. It would have been obvious to one of ordinary skill in the art at the time of the invention to use the procedures of Edelstein et al. in Joshi et al. to obtain a filled via with a combination of improved electromigration resistance, adhesion, and surface properties (Edelstein et al., Col. 8, lines 51 – 52).

12. Claim 4 is rejected under 35 U.S.C. 103(a) as being unpatentable over Joshi et al. in view of Edelstein et al. and Bogel, as applied to Claims 1 – 3, 6 – 8, 10, 13, 15, and 16 – 20, and further in view of Merchant et al. (US 6,440,849 B1).

10. Regarding Claim 4, Joshi et al. do not disclose that the copper alloy via material includes one atomic percent of Ag. Merchant et al. disclose that the alloy includes Ag

(Col. 3, line 6) and that the concentration is less than one atomic percent (Col. 3, lines 11 – 12). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Merchant et al. with Joshi et al. to provide a stable Cu alloy layer with improved electromigration properties.

13. Claim 9 is rejected under 35 U.S.C. 103(a) as being unpatentable over Joshi et al. in view of Edelstein et al. and Bogel et al., as applied to Claims 1 – 3, 6 – 8, 10, 13, 15, and 16 - 20 above, and further in view of Gross (US 6,380,083 B1).

12. Regarding Claim 9, Joshi et al. do not disclose the grain size of the copper layer (after annealing). Gross discloses that the grain size increases to sizes greater than or equal to 2  $\mu\text{m}$  (Col. 5, lines 30 – 36). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Joshi et al. with Gross to obtain copper layers of stable grain size for improved device performance.

14. Claims 11 and 12 are rejected under 35 U.S.C. 103(a) as being unpatentable over Joshi et al. in view of Edelstein et al. and Bogel et al., as applied to Claims 1 – 3, 6 – 8, 10, 13, 15, and 16 - 20 above, and further in view of Andricacos et al. (US 6,090,710)

15. Regarding Claim 11, Joshi et al. do not disclose a ternary copper alloy via material containing at least 98 percent copper. Andricacos et al. disclose that the addition of an alloying element in the range, 0.01 and about 2 weight percent (Col. 8, lines 15 – 16)



with at least 98 percent Cu. It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Andricacos et al. with Joshi et al. to obtain low resistance (resistivity) copper alloys for vias.

16. Regarding Claim 12, Joshi et al. do not disclose that the ternary copper alloy via includes Sn. Andricacos et al. disclose (Col. 8, Table 1) that Sn is included in the via. It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Andricacos et al. with Joshi et al. to obtain low resistance (resistivity) copper alloys for vias.

17. Claims 21 and 22 are rejected under 35 U.S.C. 103(a) as being unpatentable over Joshi et al., in view of Edelstein et al. and Bogel et al., as applied to Claims 1 – 3, 6 – 8, 10, 13, 15, and 16 - 20 above, and further in view of Merchant et al.

18. Regarding Claims 21 and 22, Joshi et al. do not disclose that the element for increasing grain size is Cr or the stuffing of grain boundaries. Bogel et al. disclose that the element for increasing grain size is Cr (Col. 7, line 65 through Col. 8, line 10) (Figure 3) and that the concentration is that the concentration is 0.4% (less than one atomic percent) (Col. 7, lines 65 – 67). Further, Merchant et al. disclose (Col. 2, line 62 through Col. 3, line 3) the motion of dopant or alloy element to grain boundaries to produce pinning and “stuffing” of grain boundaries. It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Bogel et al., Merchant et

al. and Edelstein et al. with Joshi et al. to provide a stable Cu alloy layer with improved electromigration properties.

19. Claim 23. is rejected under 35 U.S.C. 103(a) as being unpatentable over Joshi et al., in view of Edelstein et al. and Bogel et al., as applied to Claims 1 – 3, 6 – 8, 10, 13, 15, and 16 - 20 above, and further in view of Gross.

20. Regarding Claim 23, Joshi et al. do not disclose the grain size of the copper layer (after annealing). Gross discloses that the grain size increases to sizes greater than or equal to 2 um (Col. 5, lines 30 – 36). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine Joshi et al. with Gross to obtain copper layers of stable grain size for improved device performance.

### ***Response to Arguments***

21. Applicant's arguments with respect to claims have been considered but are considered to be non persuasive. The commentary regarding the non-presence of a barrier layer at the sides and bottom of the via is incorrect (pp. 6 – 7, Response). The via structure (10) (Figure 1) (Col. 4, lines 32 – 35) is present atop the M1 layer. Layer 46 is not a part of layer M1, and as such, is at the bottom of the via. Along the sides of the via, layer 40 is present. It is not germane that the thickness of the shoulder portion is small. There is no recitation in the claim limitations which states that the barrier layer “extends” along the lateral sidewalls and bottom

of the via aperture. Further, regarding Claim 10, the reference shows a "conformal" (adhering to the shape or size of") layer "at" ("presence in or on") the bottom and sides of a via aperture. Edelstein and Bogel et al. are combined with Joshi et al. to obtain copper alloy for the via. The remaining arguments relating to the patentability of dependent claims based on the patentability of independent claims is incorrect, based on the above.

### ***Conclusions***

22. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the Examiner should be directed to **Thomas Magee**, whose telephone number is **(571) 272 1658**. The Examiner can normally be reached on Monday through Friday from 8:30AM to 5:00PM (EST). If attempts to reach the Examiner by telephone are unsuccessful, the

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examiner's supervisor, **Eddie Lee**, can be reached on **(571) 272-1732**. The fax number for the organization where this application or proceeding is assigned is **(703) 872-9306**.

A handwritten signature in black ink, appearing to read 'Eddie Lee', with a large, sweeping initial 'E'.

**EDDIE LEE**  
**SUPERVISORY PATENT EXAMINER**  
**TECHNOLOGY CENTER 2800**

Thomas Magee  
December 28, 2004